Course Name: Brain Computer Interaction (BCI)

Date: 20th April 2021 (Spring 2021)

Exam Duration: 1 hour 20 min **Total Marks:** 25

Instructions:

1. This is a closed book, closed notes exam. There are 5 questions and each carries 5 Marks. Attempt all questions. No choices are given in the question paper.

2. You should not discuss questions or answers with anyone (including outsiders)

3. You should have your camera ON at at all times and no headphones

4. Write down your answers in the A4 sheet. And be brief and to-the-point. Answers must be given in ***blue ball point pen*** only. Answers in pencils will not be checked.

5. The coding based question can be solved using matlab or python. You have to submit a .py or .mat file for code and also submit other supplementary files if any.

6. The name of the scanned copy should be the Roll No + '_' + Set No.pdf. (e.g.,S20170010XYZ_SetA.pdf). Write the name and the roll no. on each page of the answer sheets.

7. The naming convention for the file with code should be Roll No + '_' + Set No.py(.mat). (e.g.,S20170010XYZ_SetA.py(or.mat)).

6. Follow all other instructions given by the faculty during the exam.

---------- All the best----------

Q1. Explain how PCA achieves: [5]

1. Dimensionality Reduction
2. Decorrelation
3. Reconstruction of inputs

Q2. Plot the ROC curve and write down the accuracies (ACC) for a classifier that exhibits the following performance as you vary one of its parameters. Assume that the number of positives in the training data set is 50 and the number of negatives 30. [5]

a. 5 false positives, 25 false negatives

b. 10 false positives, 5 false negatives

c. 20 false positives, 0 false negatives

Q3. Each node in a decision tree performs a test on one or more input variables, and the outcome of the test dictates which branch to take. Describe how a ID3 based decision tree can be constructed from a labeled bootstrap sample. In particular, at each node, given a subset of m randomly selected input variables, how do we find a test of these m input variables that best splits the sample into two separate classes? [5]

Q4. Given the signal [5]

$$x(t) = \sin(2\pi f(t)\, t) + \omega(t)$$

Generate the signal in matlab/python, choose a proper sampling rate for generating the time support 't' and let f(t) = a*t^3

Using fft algorithm generate and plot the spectrum corresponding to the frequencies f(t)

Describe the result

Noise of the signal can be chosen as 0.01. Choose a = 250Hz.

Q5. Consider neural networks whose neurons have linear activation functions, i.e., each neuron's output function is g(x), where x is the weighted sum of inputs to the neuron, and b and c are two fixed real numbers.

a. Suppose you have a single neuron with a hyperbolic tangent activation function g(x) with input u0, . . . ,un and weights W0, . . . ,Wn. Write down the squared error function in terms of the input and weights if the true output is d.
b. Write down the weight update rule for the neuron based on gradient descent on the error function in (a).
c. Now consider a network of linear neurons with one hidden layer of m units, n input units, and one output unit. For a given set of weights wkj in the input hidden layer and Wj in the hidden-output layer, write down the equation for the output unit as a function of wkj, Wj, and input x. Show that there is a single-layer linear network with no hidden units that computes the same function.
d. Given your result in (c), what can you conclude about the computational power of N-hidden-layer linear networks for N = 1, 2, 3, . . .?